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[The following are translations of selected articles in the Russian-language monthly journal AVIATSIYA I KOSMONAVTIKA published in Moscow. Refer to the table of contents for a listing of any articles not translated.]

Long-Range Aviation CinC on Status, Prospects of Strategic Forces

92UM0465A Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 10, Oct 91 (signed to press 19 Sep 91) pp 2-3

[Interview by AVIATSIYA I KOSMONAVTIKA correspondent with Long-Range Aviation Commander-in-Chief Colonel-General Aviation I.M. Kalugin under the rubric "Topical Interview": "In the 1st Strategic... *They Distinguish the 1st and 2nd Strategic Echelons in the Armed Forces of Our Nation*"]

[Text] *The 1st... It is composed of large units and formations intended for the execution of the first operations. These are missiles and submarines... The same mission is entrusted to strategic aviation as well. We have 162 heavy bombers, which have 855 nuclear charges (8.3 percent) according to established rules. The SNV [offensive strategic weapons] of these three types of basing also constitute our strategic triad. How is combat training going for the "long-rangers"? What changes are projected in the course of military reform? A correspondent from the journal discussed this and other things with Long-Range Aviation Commander-in-Chief Colonel-General Aviation Igor Mikhaylovich Kalugin.*

[Correspondent] Igor Mikhaylovich, let's start with the fact that you recently visited Estonia recently "on needs of state." You have a pretty good-sized "operation" there. What sort of a trip was that?

[I.M. Kalugin] Who is our country is not asking about assistance today? You would agree that service in the Baltics nowadays is no picnic. In Estonia, say, which has now gained independence. Prices for foodstuffs and industrial goods have doubled or tripled. Wages have gone up by the same amount... for local inhabitants. And the servicemen? They have ended up outside the "field of view." What can be done for them?

I visited the flight mess—a very, very poor table. And the families of the fliers? They can barely make ends meet. That didn't happen before. There are many complaints of social injustice and lack of protections. We will help them. We will procure foodstuffs and goods in other regions, and send them there by aircraft!

What else is bothering people? Getting set up in life after discharge, whether they will have anywhere to settle, the withdrawal of troops... For example, they have established twelve levels of knowledge of the Estonian language in the republic today, I believe. With the lowest level you can work only as a janitor.

The situation seems to be normalizing all the same. There is no outright confrontation. That is comforting. We have to wipe away the grains of mutual distrust. More truth and openness. There is a constructive program on that score in the local air garrison. It is already being realized. I would hope that in the shortsightedness of the political struggle and the cheerlessness of economic problems we have not forgotten the main thing—combat readiness. As for our own formation stationed in Estonia, I will say outright that there are no apprehensions concerning its combat readiness. One of the regiments, commanded by Colonel Proskuryakov, recently underwent an inspection—the rating was excellent!

[Correspondent] Igor Mikhaylovich, what is "troubling" your fliers anyway?

[I.M. Kalugin] There are problems that we can and should solve ourselves. The results of the current training year show that there is not complete well-being in all the units of LRA [long-range aviation]. This includes the poor quality of flight shifts, breaches of flight discipline, methodological flaws and other things. All of this is forcing all of us to think seriously. We have done a critical analysis of many aspects of the organization of combat training. It must be owned that the results of the fliers' work used to be evaluated in such a way that it provided no incentive for a rise in the qualitative indicators of combat training. What did predominate? General numbers. We have now begun to study each sortie more closely, analyze each weapons delivery, ascertain the causes and specific offenders in all mistakes and take steps to keep them from happening in the future.

The commanders of the regiments have raised their exactingness toward executors, have begun to devote more attention to the organization of preparations for flights and have a more attentive attitude toward the desires of subordinates and their needs. This pertains to the daily routine as well. A workday without norms is often transformed into an "unlimited" day. And that in no way facilitates its effectiveness, and fatigues and annoys people. It seems to me that it is time to reject measures that are carried out just for the "check-off," and out of which formalism and stagnation flow... How many years have we been talking about computerizing the process of combat training? All we do is continue to talk. This is not a problem that we can solve with our own manpower, it is a more sweeping one.

[Correspondent] Igor Mikhaylovich, long-range aviation has undergone quite a few of its own types of reorganization over its history. Isn't it threatened by the latest "corrections"?

[I.M. Kalugin] The history of long-range aviation really does abound in various metamorphoses. The group of heavy aircraft, air brigades and corps and them special-purpose armies. On the eve of the Great Patriotic War those armies were abolished and reconstituted into the Long-Range Bomber Aviation of the High Command (DBA GK). Then the Long-Range Aviation (ADD). After the war the ADD began to be called long-range aviation. The essence is not the names, of course, but its purpose. I am deeply convinced that the role of long-range aviation has currently increased immeasurably.

It must without fail be preserved. We will, of course, have to cut back some regiments. They will be, by and

large, those whose aircraft have been in service for 30-35 years. We still need people as before. The engineering and technical staff alone is short some 22,000 people. This process, I think, will not proceed painlessly. It is better, after all, to have a small quantity of regiments that are fully manned. Each will then be working only for himself, the workday will be straightened out and the specialists will get time for full-fledged relaxation and for their families.

[Correspondent] The tactical proficiency of the pilot is, as is well known, the linchpin of the fighting ability of aviation subunits. Everyone would seem to acknowledge that in word. One always hears that they should be taught what is needed in war. But the shame is that we are talking a great deal, but we are doing far from everything necessary for that...

[I.M. Kalugin] Yes, that happens. So incidents are frequent where a relaxation of demandingness and omissions are permitted, where flights take place under eased conditions, where there can be no discussion of inquiry or creativity. That has happened with us too in a number of cases. Some commanders try to justify it—we are not sitting with our arms folded, they say. The airfield does not know quiet day or night. That is all true. But take a look at it more closely—it is of little use. Here they are playing it safe, there they have deviated from the flight rules, there they overlooked something. And, as a result, flight accidents, poor ultimate results. We will simply be parting ways with such commanders.

Tactical devices are always being developed by the pilots and navigators themselves in the advanced regiments. The methodological councils provide every encouragement for such initiative, and facilitate its realization.

Exactingness has also increased toward evaluations in defeating air defenses and tactical launches. Our crews have begun to execute them three times more often than before. All are gladdened by that.

The fact that flying time lags behind the theoretical norms, as before, continues to be distressing. That is not our fault here. Much depends on the equipment and its service life. We have to "conserve" it so as not to use it all up at once. There are also difficulties with POL [petroleum, oils and lubricants]. We have made the decision, and not just to take it easy, to fly only on fixed routings with the expensive aircraft. We use the Tu-134 UBLs in the area of the airfield, for defensive circles. The necessary quantity of such aircraft has already been determined. We are devoting the most steadfast attention to simulator training. We can prepare for any flight on the ground.

[Correspondent] A great deal has been written and said about the Tu-160—the "Blackjack," as it is called in the West. What is your opinion of that aircraft?

[I.M. Kalugin] It may be a good aircraft. The pilots praise it—it is easy to fly—but it is very expensive. It is complicated to service. It needs a special airfield (the hydraulic pressure is high), a large quantity of ground-support equipment, the IAS [aviation engineering service] specialists need protection against the noise... It demands, in short, a very large supply train. The Tu-160 overall is an appreciable leap forward in domestic aircraft building. But the design must still be worked on. An aircraft that is convenient in all regards and less expensive is needed. Today we have to count every kopeck, after all.

[Correspondent] Igor Mikhaylovich, there are quite a few units and subunits in LRA that operate without accidents. What is the secret? Perhaps they aren't flying very much or they have improved equipment?

[I.M. Kalugin] No. The rate of flight operations and the yearly plan for combat training in those units are no less than in others, and the equipment is the same. The attitude of the people toward their business is more responsible. The commanders can be offered as an example of that. A climate of high exactingness, of constant monitoring of the degree of readiness of the crews and the equipment for flights, has accustomed people to conscientiousness and thoroughness and has cultivated the habit of doing everything the way the guiding documents require. That is just how they proceed in the aviation units where comrades Grebennikov, Yakunov, Gorgol and Bashkirov, among others, are serving. Their work practices confirm that one can operate without preconditions for flight accidents.

[Correspondent] So what keeps the other aviation commanders from getting rid of instances of negligence, lack of discipline and a lackadaisical approach toward the performance of an important task—accident-free flying?

[I.M. Kalugin] The principal reason is the fact that some commanders have not completely understood the essence of the changes that have occurred in aviation, and are continuing to work in the old style. We must fundamentally alter the style and method of leadership and the organization and execution of combat training, and concentrate our attention on the profound and comprehensive mastery of the combat equipment and the moral and psychological preparation of the crews for each sortie. Violations of the rules of flight work automatically lead to a drop in combat readiness. And flight safety and combat readiness, after all, are interconnected. No one has the right to forget that.

[Correspondent] A final question. The USSR Minister of Aviation, Marshal Aviation Ye. Shaposhnikov, has named four chief parameters for the general direction of the transformation of the army. What can you, Igor Mikhaylovich, say on that score?

[I.M. Kalugin] I know those parameters well. They are simply essential for long-range aviation in particular. It is long since time to resolve issues of professionalization, the quality of equipment, the democratization of military service and the assurance of reasonable sufficiency in the defense of the country. All must do this, do it

without fail, if we do not want to squander the foundation of the armed forces—the officer. We must all extract the most serious lessons from former shortsighted decisions and learn to look to tomorrow. Not only servicemen, but all of our people should have an idea of the future of their armed forces and the concepts for their reformation.

Improvements Proposed in Handling of Aerial Reconnaissance Data

92UM0465B Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 10, Oct 91 (signed to press 19 Sep 91) pp 4-5

[Article by Candidate of Military Sciences Lieutenant-Colonel A. Klyuchnikov under the rubric "For High Combat Readiness": "Under Conditions of a Shortage of Time"]

[Text] Successful combat operations depend to a considerable extent on how much the commanders and staffs of all ranks and levels are acquainted with the functional and compositional nature of the opposing groups of enemy forces. It is no secret that the interested parties are provided with that information by the forces of all branches of reconnaissance, including special aerial reconnaissance units and subunits. They are equipped with manned and unmanned systems fitted with modern technical means of reconnaissance whose operation is based on various physical principles.

The practice of utilizing those means shows that the overwhelming majority of them provide for the receipt of reconnaissance information according to the configuration: flight to the enemy target—reconnaissance—delivery of the information media—its processing on the ground—receipt and depiction of reconnaissance data. This functional cycle for the system of gathering the essential information, however, provides for the receipt of the essential information only an hour to an hour and a half after the landing of the reconnaissance aircraft. The use of information on the enemy in the interests of assessing the situation and making decisions for combat operations—taking into account the time expenditures for returning from the search areas and the receipt and transmission of the reconnaissance data to the interested headquarters—should thus in fact not be expected any sooner than two or three hours after the performance of aerial reconnaissance (VR). Such a time indicator does not correspond to contemporary requirements under conditions of highly maneuverable and fast-moving combat operations (the war in the Persian Gulf being graphic confirmation of that).

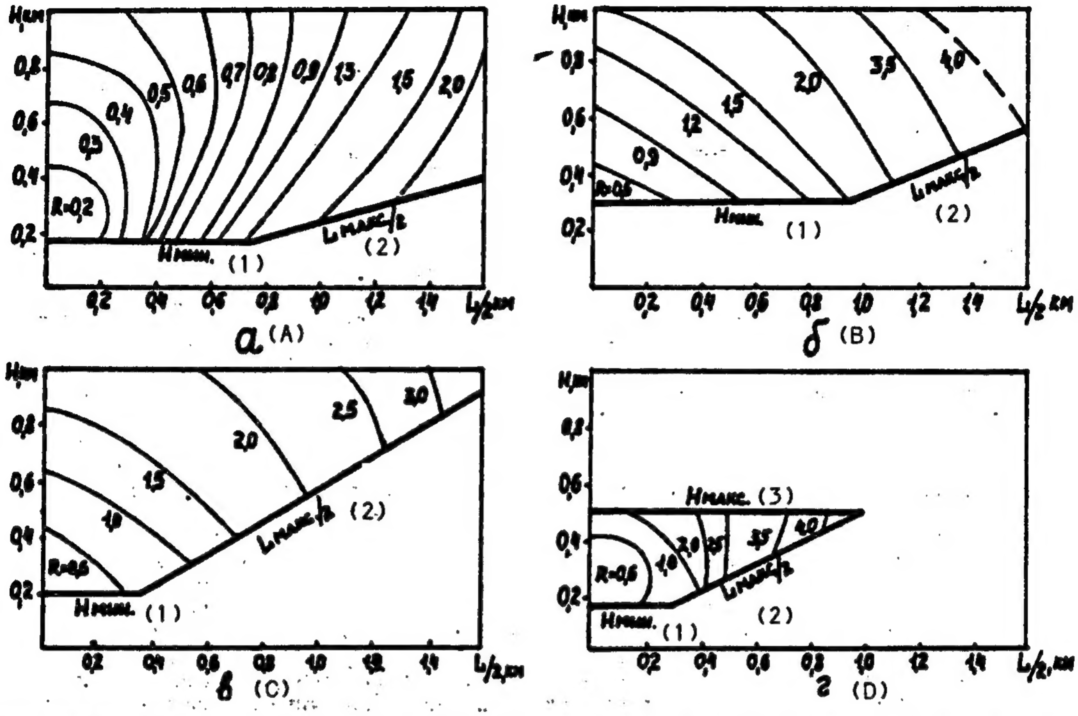
There is no doubt that the greatest losses of time occur at the stage of the delivery of the information media to the landing airfield and their processing. It is thus entirely logical that that time interval must be reduced to a minimum in order to increase the timeliness of aerial reconnaissance in modern battle via the receipt of information in real time through further improvement of the means of aerial reconnaissance.

The realities of our time, however, dictate their own conditions: the practices of combat training show that those means coming into service with reconnaissance aviation are not solving the problems, since the requirements of the customer—the Air Forces—were not fully taken into account in their development. One unfortunately should not expect the creation of new and more advanced means of aerial reconnaissance in the near future, for wholly understandable reasons. The only thing that remains is to modernize the existing reconnaissance equipment. But who will shoulder that work?

Enthusiasts have been found. A group of scientists at the VVA [Air Forces Academy] imeni Yu.A. Gagarin and the VVIA [Air Forces Engineering Academy] imeni Professor N.Ye. Zhukovskiy, in collaboration with the staff members of one of the Air Forces NIIs [scientific-research institutes], has conducted a series of research whose results have shown that a significant reduction in the time periods for the receipt of reconnaissance data can be achieved through equipping electro-optic reconnaissance equipment with indicators or a display board for real-time information. The presence of such equipment, for example, on board a reconnaissance aircraft would allow its crew to discover the assigned targets, determine their coordinates and transmit by telemetric, shortwave or ultra-shortwave radio communications to the interested parties virtually in real time. The results of the first research flights using this system have exceeded all expectations—the sets of new equipment installed on board several aircraft and in the ground command post made it possible to transmit information from the reconnaissance equipment to indicators on strike aircraft and to the ground in automatic mode over just one and a half to two minutes. Success? Undoubtedly! It would seem that it is just a matter of industry now. But how many times have we had to complain about interdepartmental red tape—in the swamps of which excellent scientific ideas and engineering solutions are drowning to this day?

All that remained, meanwhile, was to work on improving the process of processing and presenting the reconnaissance data. It is proposed that video recorders be used as the means of documenting the information coming in from on board the aircraft, which would make it possible, first of all, to reject the prolonged process of the negative and positive processing of photographic materials and, second, to use the information recorded on the video tape as a document confirming the fact of the performance of reconnaissance against the assigned targets, and moreover transmitting the data obtained to the interested headquarters in operative fashion.

The process of deciphering the reconnaissance data begins from the moment of its arrival at the command posts of the aviation units, formations or large units. It should be noted that modern electro-optic means of aerial reconnaissance possess quite good properties in



Dependence of the width of the effective strips of aerial reconnaissance from flight altitudes of aircraft equipped with panoramic aerial cameras (a), television (b), infrared (c) and laser (d) systems.

Key:
1. H_{min}
2. $L_{max}/2$
3. H_{max}

the breadth of sweep of the terrain. They cannot always discover the assigned targets across the whole field of reconnaissance, however, but only in a certain part of it. It is thus expedient to calculate the width of this strip in advance using the following example: $L_{ef} = 2H_i tg(\alpha + \beta)$ (where H is the altitude of the search, α is the angle of inclination of the optical axis of the instrument, and β is the running angle of the scan of the terrain). It is also necessary to take into account herein that the altitude of the search is defined as $H = 2R_{tr}K_v \cos\beta$ for panoramic aerial cameras (where R_{tr} is the require linear resolution on the terrain, and K_v is the perception factor); $H = (R_{tr}/tg\varphi_r)\cos\beta$ for infrared and laser reconnaissance (where φ_r is the angular resolution capability of the reconnaissance equipment) and $H = R_{tr}N_{str}f\cos(\alpha + \beta)/3l_{fk}\cos\beta$ for television reconnaissance equipment (where N_{str} is the number of lines per reference frame, and l_{fk} is the length of one side of the photocathode of the television tube).

Graphs of the effective strips are later constructed for each type of technical means of reconnaissance (see figure). These calculations make it possible to cut by two thirds the process of deciphering the information coming in to the command posts.

It must be emphasized, aside from this, that the objectivity of the data on the enemy in the course of combat operations will depend as well largely on the organization of the aerial reconnaissance, which is made much more complicated today due to the presence of various types of forces and assets in reconnaissance aviation. This in turn cannot help but have a ruinous effect on the process of planning aerial reconnaissance, which abounds in labor-intensive calculations of the effective utilization of its combat potential.

It is well known that the use of computer technology would help break these bonds. Aerial reconnaissance and computers!? Quite recently, literally five years ago, that phrase sounded rather fantastic, since an irrepressible "computer hunger" existed among the troops, and an acute shortage of programmers of the highest class who could have been able to develop a set of operational-tactical tasks for the organization of aerial reconnaissance was being felt. Such work was nonetheless being performed and its volume was growing—with great growing pains, it is true—to the extent of the adoption of computer technology into the training process in the Air Forces. And it is gratifying to note in this connection that the initiative group of scientists from the VVA imeni Yu.A. Gagarin that set about the development of those

tasks has received substantial support from representatives of the Reconnaissance Directorate of the Air Forces Main Staff. The results of their work are a significant reduction in time expenditures for the organization of aerial reconnaissance in aviation formations and a rise in the share of intellectual labor by the officers of reconnaissance bodies and staffs at all levels.

One nonetheless cannot fail to say that heavy work to realize the proposals set forth herein lies ahead. The main thing is clear—without close interaction between basic science and field practices, all the problems that exist in the organization of aerial reconnaissance will not be solved. It would be worthwhile to clear away all the obstacles lying on the path from theory to practice without wasting any time, despite the fact that that path is both long and hard.

Intermittent In-Flight Equipment Problems Often Go Unrepaired

92UM0465C Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 10, Oct 91 (signed to press 19 Sep 91) pp 6-7

[Article by Honored Military Navigator of the USSR and Candidate of Military Sciences Colonel (Reserve) V. Dudin under the rubric "Flight Safety: Experience, Analysis, Problems": "Both Strength and Precision..."]

[Text] The deputy commander of the fighter-bomber squadron, Combat Pilot 1st Class Captain Vladimir S., executed the takeoff and turned his aircraft onto the first stage of the flight heading in an excellent mood. Finally, after an involuntary two-week layoff caused first by assemblies of the command personnel and then a cyclone that had come in off the sea, the long-awaited flight day had arrived.

The captain was to perform a flight to the practice range on a heading with a variable configuration, and then perform bombing in automatic aiming mode—an interesting and desirable assignment.

The pilot's optimism, however, began to diminish as early as six minutes into the flight—the readings of some of the instruments for the on-board equipment depicting the maintenance of the assigned routing began to behave, as they say, in non-regulation fashion. The meter for the distance to the turning point suddenly stopped, and then started up with a jerk toward increased readings. The pointer of the aircraft heading indicator arbitrarily started "floating" downward. The signal light for a failure of the azimuth channel of the short-range radio navigational system (RSBN) came on. To top off all of this, the voice of the tactical-control officer sounded in the earphones of the helmet intercom: "83, deviating right, drift angle 25. Return to proper heading!"

The pilot got onto the assigned routing with a correction to the heading, clarification of the direction according to the radiocompass, by request for a bearing and according to the lateral distance of a characteristic cape on the shoreline that was revealed through an opening in the clouds. The operability of the navigational equipment had seemingly been restored, and Vladimir concentrated on reaching the start of the bombing run, finding the target and aiming.

Things did not get by without surprises there either. The on-board rangefinder issued an erroneous distance to the target—it did not coincide with the data from the flight operations officer (RP) at the bombing range. The target lock-on was unstable, and the aiming mark periodically slipped off it. Then the mark stopped on the target, and the pilot made the decision to drop (they don't give you any praise for a "dry" run). But his results proved to be at the edge of an acceptable evaluation. The equipment was again operating unreliably in the second pass, and after the pilot's report the flight operations officer at the range banned the operation. There was not a trace left of the captain's good mood.

After landing and taxiing the pilot reported what had happened to the specialists of the IAS [aviation engineering service] and intended to make a notation in the logbook for preparing the aircraft. But while he was thinking about just how to phrase and fit everything he saw on the flight into the limited space of the form, suitable just for entries of the "bulb burned out" or "radio failed" type, the regimental commander and the deputy for political affairs came up to the aircraft. "So, you did great, sharpshooter?" they said with reproach. The captain was silent; there was no point in trying to justify oneself—the time for the next sortie on a trainer as an instructor was approaching.

When the officers had left, the technicians suggested making the entry later (the aircraft would not be flying anymore on that shift), while the operability of the systems the pilot had complaints about would be checked. "And then," they continued, "we'll record them together, so to speak, setting it all out in substantiated and technically literate form..."

The captain, having completed his flight to the practice area with his trainee, came back to the hardstand of the first aircraft. The regimental engineer was descending from its cockpit on the ladder. "Everything works fine," he said, and suggested "Let's run it on the current together after the flights." "Let's fly out to the practice range together!" answered the pilot angrily. After the flights he had to be the "birthday boy" at a debriefing (they had already warned him), then rough out the flight-operations schedule for the next flight shift and do other "deputy's" duties. "The equipment must be used correctly," retorted the engineer, and added, "Sorry about the graded tests..."

Thus was realized once again the axiom, exceedingly widespread in modern aviation, for evaluating the functional quality of the "pilot—aircraft" system. If the mission goes fine, that means the craft worked well, it is

saturated with all kinds of automatic equipment for that purpose. If there is a deviation from the assigned routings, the inaccurate aiming of the weaponry, a mistake in determining coordinates for the target being covered or some other unfavorable but, unfortunately, far from isolated thing familiar to many fliers, then the pilot, the navigator or some other crew member is to blame. It is becoming more and more difficult to separate the blunders or inattentiveness of the operator (as they call any member of the crew working with the gear) from anomalies in the operation of the increasingly more complex on-board equipment. It is much simpler to complain about the person. And it often turns out that the requirements posed toward the pilot, on the one hand, and the hardware he is operating, on the other, are formulated and implemented in far from suitable fashion.

The pilot is always in the public eye. He is taught many disciplines (too many, they are beginning to feel), he takes a lot of graded tests, he is systematically subjected to checking and monitoring on the ground and in the air, and his mistakes are revealed and taken into account by the commanders, instructors and specialists from many services—both flight and ground. Every movement and word of his (and, in the not-too-distant future, his pulse and respiration) are recorded by objective monitoring equipment. And all of the higher echelons, including some with exceedingly remote connection to flight activity and the limits of pilots' capabilities, demand of him: know everything of ours by heart! Be efficient and dependable, and take initiative at the same time! And, most importantly, everything must go fine in our area in flight, nothing can happen. Otherwise you will be blamed and inundated with documents, and there are more than enough of those—not to mention specialists—for one solitary pilot.

How do matters stand with the requirements posed toward the good working order of the hardware, that second component of the indivisible "pilot—aircraft" system? Here, as is well known, a streamlined system for preparing the aviation hardware, monitoring its readiness and, finally, accounting for failures that are manifested—with their subsequent elimination—has been functioning here for decades. It turns out in practice that the depth of execution of the operations in technical maintenance is far from identical for various assemblies and systems. Proceeding from this, the latter may be hypothetically divided into two groups—not, of course, codified by any standard documentation, but nonetheless having an exceedingly clearly sketched functional purpose.

The first is assemblies that directly support the process of flight from takeoff to landing. They are the engine (the power plant), the takeoff and landing devices and the control and power-supply systems, among others. Their operability is monitored unwaveringly, and their actual condition has only two unequivocal and mutually exclusive properties—in working order or not in working order (works or doesn't work). They are manifested in trustworthy fashion both on the ground and in flight, both for the pilot and for the technician. Varying interpretations and formalism are virtually ruled out here.

The second is equipment that supports navigation and all types of weapons delivery. This equipment, distinguished by an ever-increasing structural complexity, is exceedingly sensitive to flight conditions. Disruptions of its operability, as opposed to the equipment in the first group, are manifested not in the traditional manner of "working or not working," but in a fundamentally new way—"working, but with disruptions in properties of accuracy, unstable."

Different rules are in effect here than for servicing equipment in the first group. It is not possible, first and foremost, to obtain in ground checks the entire dynamic of the functioning of all elements of the equipment that takes place in an actual flight. The intermittent operation of an instrument in the air is moreover of a reversible, "floating" nature—first everything is fine, then there is an imbalance, and by the end of the flight (or even after the landing) it is restored once again. It is exceedingly difficult to detect such a stray defect, as they say, on the ground.

That is namely why a substantial distinction has arisen and become widespread in evaluating the operability of a considerable portion of the on-board equipment by flight and technical personnel. And the last word unfortunately is far from always with those who perceive the whole real picture of the system operation in flight. An emotional post-flight story from a pilot who has not yet "cooled down" from tension is very often received by the IAS specialists from a critical standpoint. And it never reaches the point of recording the defects.

There is the objective monitoring equipment [SOK], of course. But it records first and foremost the actions of the pilot or crew, the operability of equipment in the first group, the settings of the controls and the basic parameters of the flight. Despite the importance of that data, it is not always able to be evaluated by in-flight monitoring on all aircraft during the course of flights. The precision and stability of operation of the navigational and aiming systems are not evaluated within the limits of the whole aircraft inventory with the aid of the SOK due to the lack of clear-cut standard requirements and the insufficient informativeness of the monitoring devices themselves. But if the pilot allows excessive G-forces for a couple of tenths of a second, it is all right there, and one person—the pilot—is of course to blame.

One may judge the quality of operation of the on-board equipment, aside from the reports of crews and analysis of SOK data, with the aid of yet another reliable method—check-ups on test flights. But check flights to measure the precision features of on-board equipment are not envisaged. The engines are tested after replacement and repair, as are ground landing, bearing and communications systems, but the navigational and weapons-delivery equipment on board even the heaviest aircraft making flights lasting days or more is not. It is not stipulated—period. Once again too costly, the expenditure of fuel...

The sources for the gathering and accumulation of data on the actual operability of the navigational and aiming equipment in flight are thus only partially effective. And this weakens the feedback—from the flight personnel to the IAS specialists and on—to the manufacturers and developers of the aiming and navigational equipment. This situation suits many, since it engenders a tolerant attitude toward shortcomings.

This equipment thus operates in precise and stable fashion on far from every flight and on far from every aircraft or helicopter. Such facts as the poor precision of the automated reckoning of the route and determination of the coordinates of the aircraft's location, or instability in the tracking and lock-on of targets, are far from isolated. But it very often turns out to be difficult for the pilot or crew to record and prove this, and it is often not expedient for them.

But this situation is intolerable from more than the viewpoint of professional protections for the flight personnel alone, even though it is no less topical than the lack of social protections that has attracted so much attention lately. Much more serious is the fact that this reduces the confidence of some of the fliers in the guaranteed reliability of the aircraft they are taking up into the air.

The imprecise and unstable operation of navigational and aiming systems in the everyday practices of the aviation units leads to dangerous consequences. First and foremost, they reduce safety in the performance of flight assignments, which could lead to a flight accident with the insufficient professional training of the pilot or crew.

Poor-quality operation of the bombsight and navigation system (PNK), on the other hand, leads to the fact that in crucial exercises, especially with the presence of the high command, many of the drills are carried out with the exceedingly single-minded assurance of a hit "by each shell, bomb or missile on the target," which would probably not be possible in a real combat situation. The deployment of additional radio and navigational aids—right up to radio beacons on the target heading, the simplification of the maneuvers, the intentional breaching of target camouflage and other "tricks" unknown to those on the reviewing stand—are employed therein.

And finally, a considerable number of the flight personnel do not use certain PNK devices at all owing to their poor precision in certain modes or across the whole spectrum. That was the fate, for instance, of the BTs-63 astrotracker or the back-up circuits for course reckoning in some methods of correcting the coordinates of the navigational systems, as well as aiming or structuring the landing approach. The output parameters are within the certified performance characteristics on one or two pilot copies in state testing of this equipment, serviced by highly qualified specialists of the developer enterprises and used by experienced (but unfortunately not always disinterested) test pilots and navigators. But life in the formation inexorably weeds out stillborn innovations. And these units and control panels are carried around as useless cargo, taking up space in the cockpits of dozens of aircraft. This unpleasant but objective information never reaches the inventors of these devices (and are they all that interested?). There are still few real changes for the better, and they do not affect even items in the latest generations.

Is that not why, in the face of the undoubtedly high aerodynamic and durability properties of our combat aircraft—as noted at all recent international exhibitions—the precision characteristics of their equipment compared to comparable foreign models are, to put it mildly, not in our favor, and that difference is not being reduced very quickly. There is no doubt that an artificially created sense of well-being in the resolution of these issues stimulates this conservatism, and markedly reduces combat readiness and the prestige and competitiveness of domestic aviation systems.

The experience of operating PNK shows that a fundamental accounting for its actual operability could be ensured in its entirety with improvements in the system for gathering and processing information, starting at the "squadron" level. It would be expedient to develop for this purpose formalized log forms for the quality of operation of the principal instruments of PNK systems—the navigational computer, the heading system, the on-board radar, RSBN and DISS [Doppler speed and drift meter], among others. The pilot or crew should have an opportunity to record or note all failures of the equipment that are observed in flight. The introduction of a logbook for the navigational personnel for shortcomings in PNK operation is very expedient on multiseat aircraft. Summary data on the operability of the bombsight and navigation system equipment (over a certain time period) should be reported not only to the IAS, but also to the navigational service. This would also compensate for a shortcoming in the existing system, when the service that performs the technical maintenance of given equipment reports on the quality of its operation, but does not operate it in the air.

Maximum use must be made of the SOK (MSRP, Tester types) to raise the true level of information on the precision and stability of PNK operation. The current values of the azimuth and range from the RSBN beacon, the coordinates of the location, the drift angle, the parameters of target tracking or the target of aerial reconnaissance should be recorded continuously. Only then will it be possible to reconstruct the actual dynamics of the readings of the whole system that the pilot or navigator actually saw in flight.

One of the principal directions for ensuring trustworthy depictions of the practical operability of on-board systems should be the purposeful measuring of essential parameters in the air, *i.e.* test flights. The principal portion of them could be performed as part of planned flights, *i.e.* without the planning of special sorties. The

operating precision of the PNK, for example, could easily be determined by comparing the readouts and the actual location of the aircraft. This is advisedly performed for maneuvering aircraft after a flight in the aerobatic practice zone (when approaching the compass locator), and through the performance of one or two stages of a route without corrections of the path readings (coordinates) with their subsequent execution using a precise point of reference for multiseat aircraft. Even a rudimentary comparison of the readout and actual coordinates makes it possible to assess the cumulative error in reliable fashion. This is done in practice by many navigators, but unfortunately is not accepted legally as an accounting for the actual accuracy of PNK operation—it is not stipulated by documents. This procedure is not a tangible one for the IAS specialists, they cannot get this on the ground.

The proposed methods for evaluating the actual precision characteristics of aiming and navigational equipment on contemporary aircraft should find practical application. This would make it possible, on the one hand, to raise markedly the effectiveness and safety of flights and, on the other hand, to establish reliable feedback between the developer and the operator, which will ultimately facilitate improvements in our aviation hardware.

Discouraging Working Conditions for Instructor Pilots Bemoaned

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[Article by Combat Pilot and Instructor 1st Class Lieutenant-Colonel N. Gorchakov under the rubric "From the Life of the VUZs": "Put in a Word for the Poor Instructor"]

[Text] *Years of flight-instructor work and agonizing thought about the fate of people in my profession will not permit me to remain silent anymore. I am sure that if we ourselves do not speak out at the top of our voices, no one will hear us or come rushing to our aid.*

The flight instructor is justly considered to be one of the most important figures in military aviation, insofar as he trains highly skilled aerial warriors committed to their cause. There is no place in his work for "substandard work," since that undermines the foundations of combat readiness. And while the percentage of such outright substandard work is not high in the training of flight personnel today, credit for that goes first and foremost to the instructor pilot, who is himself accomplishing his task at the cost of enormous effort and under far from favorable conditions.

I would be so bold as to assert that the system of training for flight cadres that has taken shape at the VVAULs [higher military aviation schools for pilots] over recent decades facilitates to the utmost the degradation, if one may say so, of the professionalism of the teaching pilots. The professionals are becoming dismayed and leaving the higher educational institutions, taking their cumulative experience with them. And there is no one to teach it to or summarize it for. The old is forgotten, and the new that goes beyond the bounds of what is officially permitted is prohibited. It is becoming a dream, for example, to find the textbook by G. Golubev on questions of techniques of flight training, which was published back in 1953. And there is not yet anything to replace it. And what can be said that is positive about professional protections for the instructor?

All of this, in my opinion, is giving rise to a lot of problems, the principal ones of which can be formulated as follows: a lack of correspondence between the level of training of the flight instructors and the demands made of them for the quality of cadet training, an imbalance between the material and technical support for the training process and the requirements for its quality, and a gap between the degree of everyday risk and the pay for flight work.

What is the path of emergence of the instructor like today? The desires of the cadet himself are not always being taken into account today in the selection of candidates for that post. You can count the volunteers for that position on the fingers of one hand, as they say. A newly fledged lieutenant completes theoretical training over a month after completion of the school. Over that time he becomes acquainted with the rudiments of pedagogy, psychology and the techniques of flight training. I do not want to be sarcastic, but this method of training today can really only be compared with the *likbez* [campaign against illiteracy] at the beginning of the 1920s.

The next stage is practical training. But however much the commanders from the command corps of the squadrons and the regiment strive to ensure the readiness of the lieutenants for instructional work during the day in good and bad weather conditions before the start of flights with the cadets, all of their efforts prove to be in vain. The non-conformity of the weather conditions, flight restrictions, the imperfect nature of the training course and things of that sort all hinder this.

And then they start—or rather, continue—trying to bring the young instructor up to "form" in parallel with the training of the cadets. And that is how it goes year after year. The saying that "The cadets teach you how to fly" has even taken hold among the pilots.

I would not be mistaken to say that the root of all evil is not in the negligence of the trainers or trainees, but rather in the imperfection of the whole system of training for the instructor corps. There is an appropriate order prescribing the naming of pilots from the line units to that position after the completion of the complete course of combat training. But what combat pilot would agree to replace the line unit with the school, the combat aircraft with the trainer, high pay for low pay and a

merciful regimen for the workday for the exhausting labor of the training regiment?!

My proposals, which were supported by my comrades, presuppose changes in the whole system of training the instructor pilots. Continuing along the former path would mean expending large funds for poor quality of training of pilots in this category, which will be reflected in the future in the quality of the training for cadets, flight safety and—ultimately—the combat readiness of aviation.

The proposed changes embrace the basic requirements posed toward the instructor: he should possess a broad outlook, have good qualities as an educator and psychologist, the instincts of a "pilot from God" and excellent physical conditioning. Whence it follows that the candidates for this position could be pilots who already hold the classification of pilot 1st class, who have expressed a desire (and the pay rates for instructors must be reviewed for this purpose) to work in this capacity and have received the recommendation of the methods council of the line regiment. They enter the school for instructor pilots on a competitive basis, and receive the necessary knowledge in pedagogy, psychology, techniques of flight training, aerodynamics, tactics and air navigation over two or three years. The amount of knowledge should be sufficient for them to be able to teach cadets those subjects as applied to their own type of aircraft in the future.

Practical assimilation of the profession must proceed in parallel with study of the theory: the acquisition of the ability to employ advanced methods and devices in flight training in flights. The teaching at the school should be completed with an examination and the conferring of the skills-grade classification of military pilot-instructor 3rd class.

I would be interested in knowing what regimental commander would not like to have such a pedagogue under his subordination.

Now an evaluation of the instructor's work. A sociological survey conducted at the flight schools on the topic of "What attracts you most of all to your profession?" showed that the future fliers put in first place an interest in their work, with material support in second and social and living conditions in third.

I will not focus attention on the attractiveness of instructor work, since there is more than enough interesting there. As for the material support... Here, however much this topic has been setting teeth on edge lately, we will have to dwell in more detail.

The instructor should know for the sake of what he is risking his life every day—either ending up at retirement age without rudimentary living conditions and dragging out a miserable existence (this can be seen from the example of many of the instructors who have been discharged into the reserves), or providing himself and his family with comfortable days in their remaining lifetime. He should receive—in my opinion, regardless of the position he occupies, either a cadet at an aviation school or a pilot instructor with seniority—wages in accordance with the level of danger of his work.

Economizing in pay for flight work, as we see, is already producing "results." The number of those wishing to enter the military aviation schools is decreasing with every year. Young people have become much "smarter," and the slogan of "Komsomol—to the aircraft!" alone will not tempt them there, even though attempts are made. Pilots and instructors go off to all corners of the country every year with the task of professional orientation of the youth toward aviation. I don't know about other people, but I personally experience a feeling of awkwardness from these "trips."

I agree partly with the assertion that those who are pursuing only mercantile interests have nothing to do in the cockpit of an aircraft. But they also have nothing to do there when you head off to fly with the idea of "somehow dragging along to the next payday." One must not forget that the flight personnel, as a rule, have no outside means of existence. One may conclude from this that the pilots, and especially the instructors, are waiting for a review of the pay for their difficult and dangerous work.

Now as for the lack of correspondence of the material and technical base and modern requirements for cadet training. It is fitting to recall a story here. What technical materials were the instructors using to train cadets in the 1930s? One may judge from the books one reads—the teaching process was illustrated with the aid of aircraft models (in most cases there were explained and shown only "by hand") and the crudest of simulators, made using their own manpower. I can assert boldly that in our times—the times of automation and cybernetics—the instructors are continuing to use the very same visual gadgetry. In the best case they have tape recorders and video gear, although most often they get by with slide projectors.

Allow me to ask—where are the video recorders for each flight group? Where are the personal computers that would ease the work of the instructors and rid them of tedious paperwork, where are those vaunted computers into which one could enter the essential data and, after a few minutes, receive an already finished operations schedule? It is no secret, after all, that the deputy squadron commander and the squadron commander himself have to spend a minimum of three or four hours out of a fourteen-, or sometimes sixteen-hour, work day for the compilation of the schedules... One could object that there is no money. But it is being found for the preparation and annual updating of instructional texts for the performance of flight assignments, and even in various forms—on boards, on Bristol paper and in photo albums. All of those same pilots, by the way, pore over them, updating their work through the year.

It is also of no small importance to analyze under what conditions the instructor has to fulfill his professional tasks. They may be described briefly thus: not a step without being monitored, and no initiative permitted in any case. The higher commanders, following those principles, have come to think and decide for the instructor—who has received the nickname of *"shkrab"*—and have ceased to trust him. When an instructor presents his conclusions on the inadvisability of further flight training for a cadet, for example, they do not believe him. The cadet is subjected to repeated checks, starting with the commander of the flight and ending with the commander of the regiment, or else somebody from the school administration. And he could be returned to continue flight training at any stage. I cannot recall an incident from my own practice where a "returned" cadet later astounded his colleagues with his aerobatic skills.

The workday of the instructor pilot is structured according to a tight schedule. If he is not flying, then he has to attend classes on command training, preparing himself personally and strictly according to the scenario to conduct the preliminary training for cadets for the coming flight day. There is rarely any free time left, even for the planned physical training.

The picture on flight day looks like this: a strict schedule and a scenario. The instructor and his actions, as they say, are gripped in the vice of the documents regulating flight operations. He does not have the right to decide questions of how to teach, what training methods to select or to what to devote more attention. All has already been decided for him. What could be the foundation for a feeling of responsibility on his part in such a case? A poor specialist, after all, often proves to be esteemed if he only strictly follows the prescribed rules, while a professional who tries to display independence and improve the training process often falls out of favor. Work with one eye on the superior officers instills a feeling of fear, never mind any thought of initiative or creativity. The fear in turn engenders a lack of confidence in the correctness of one's actions. I see in this a cause of the pessimistic and dispirited mood among pilots in many aviation units.

I feel it is essential, in order to improve the conditions of flight training, first and foremost not to interfere with the work of the instructor and to evaluate his work according to the ultimate results. Take away the total monitoring over each step—let him be free to determine the training program for the cadets in his group depending on their individual features. The instructor pilot should carry out his direct duties, bearing of responsibility for the theoretical training of his subordinates. There is no need to dump onto him the functions of the platoon commander as well.

It is finally also time to provide the training process with all of the essential technical materials and to review the standard structure of the training regiment, putting emphasis on the position of the instructor.

If there are no changes for the better in the near future, aviation will be deprived of the most experienced of its flight personnel, including instructors of 34-35 years of age who, growing disenchanted with their prospects, begin setting themselves up in civilian life.

Ergonomic Database Called Essential to Proper Design Engineering

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[Article by Candidate of Technical Sciences Lieutenant-Colonel A. Medenkov under the rubric "Flight Safety: Viewpoints, Opinions": "The 'Identity Card' of the Specialist—*Or, Is a Database on the Person Needed?*"]

[Text] The necessity of taking the human factor into account in the creation and assimilation of aviation hardware and the execution of measures to raise flight safety elicits no doubts among anyone today, it must be assumed. The problem of incorporating the achievements of aviation medicine, psychology and ergonomics into the practice of combat training in the units, at the same time, remains topical as before. Its successful resolution assumes first and foremost the creation of a psychological and ergonomic service, the training of the appropriate specialists and a rise in attention toward taking the human factor into account when creating modern aviation hardware. All is not in order with that here.

Ergonomic requirements are posed toward an item being developed, monitoring of their realizations is organized and expert appraisal is performed in the testing process, but there is no substantial rise in the ergonomic levels of the hardware anyway. Why? Perhaps due to the weakness of the theoretical concepts and the lack of a clear-cut system of ergonomic support for the creation of aircraft? No, although far from everything is known as yet on the general psycho-physiological laws of the activity of the operator. The main thing is seen in the necessity of improving the methodological apparatus for taking the human factor into account when substantiating the planning solutions at the design bureaus, and the organizational ones in the field. And here is why.

The planning solution, as a rule, is a compromise version of the selection of such parameters of the means, algorithms and working conditions of the person that would provide for a maximum increase in the effectiveness of his activity with a minimum of expenditures.

The organizational solution (along with the receipt of advantages alone) can also lead to the excessive expenditure of the psycho-physiological reserves of the body and, ultimately, have a negative effect on health.

A quite developed mathematical apparatus for seeking the optimal solution exists. But it assumes a formalized

description of the general psycho-physiological laws of operator activity subject to account when optimizing the parameters of processes, means and conditions for its implementation. The clear-cut determination of optimization criteria is also necessary, including such concepts and categories as "psychological compatibility," "ergonomic nature," "social satisfaction," "functional preparedness" and the like. And finally, it is necessary to know the limitations that are imposed onto the range of changes in the optimizing parameters and the expenditures of time and materials.

This in no way signifies, of course, the impossibility of the formalization of general psychic laws for the activity of the operator and the development of procedures for taking the human factor into account in the interests of creating reliable aviation hardware and rational conditions for the work of the aviation specialist.

Can we propose a path today for the rapid elimination of the gap between requirement and necessity for taking the psycho-physiological features and capabilities of the person into account, on the one hand, and the actual methodological capabilities of that accounting, on the other?

The possibility of a substantial breakthrough in the scope, level and effectiveness of the adoption of proposals for taking the human factor into account when creating and operating hardware is linked with a database for the person today. What do I have in mind? Not a simple question, insofar as there is still no unequivocal understanding of the essence, purpose and structure. Everything depends on what data about the person is needed, and in how concrete a fashion. The effectiveness and productivity of the work of specialists "on the person" will actually increase if they make use in their work of the capabilities of computer science for the storage, analysis and automated processing of information. This will nonetheless not get moving the solution of the problem of the widespread practical incorporation of recommendations to account for the characteristics of the person when creating and operating aviation hardware.

The database should act in the capacity of a methodological apparatus for the designer, commander or specialist to make decisions when the human factor must be taken into account. The conclusion that it is needed not only, and not so much, for representatives of aviation medicine as it is for the developers of the hardware and the commanders of aviation units and subunits has thus been drawn. How well-founded is it? We will try to investigate.

We will take, as an example, the ejection seat. An increase in the angle of inclination of its back would facilitate improvements in the pilot's ability to withstand G-forces. The conditions for the perception of information from the instrument panel, the view of the cockpit etc. are worsened at the same time, however. The parameters of the seat should moreover provide safety for the pilot when abandoning the aircraft. So which characteristics of the work station are the optimal ones? This issue should be decided at the very earliest stages of the design engineering of an airframe. The designer uses data on the effects of the angle of the seat-back inclination on quality indicators of piloting (execution of advanced aerobatic maneuvers, landing) and the functional condition of the person in particular to determine the optimal values.

Information on the psycho-physiological capabilities of the person is especially necessary to the organizers of combat training in the line units. One may consider as an example the performance of combat alert duty by the shift crews at command posts.

The requirements for the psychological readiness of officials to act in operative and reliable fashion have increased immeasurably under contemporary conditions. Those in turn depend substantially on the functional state of the person. That means that in order to raise the operational reliability of an alert team, it is important to choose correctly the regimen for its work and rest, determine the intelligent length for a shift and the optimal time for the start and end of alert duty. Many variations arise at once therein. Which of them is the most suitable? The solution of this problem, without using the trial-and-error method, is virtually impossible without a knowledge of the dependencies characterizing the quality of the activity and functional condition of the person under various regimens and workloads. Experimental-theoretical research conducted in that area has shown that the database will be able to aid the solution of this problem.

Attempts to staff a crew with a regard, for example, for the psychological compatibility of its members according to the data of sociometric research also look problematical without its help. It is necessary to count up a large number of variations in order to take maximum account of personal likes and dislikes. There is an opportunity, by making calculations with the aid of the database, to staff the crews with a maximum regard for the opinions and desires of its members.

But do those who are responsible for flight safety need a database on the person? Without knowing the true psycho-physiological causes of erroneous, untimely or non-optimal actions by the pilot, flight-operations group or OBU personnel or command-post teams, it is difficult to count on any substantial rectification of the accident situation or to establish the general laws for their appearance and the circumstances of their manifestation. And there is no doubt, of course, of the fact that information accumulated in that way could be utilized effectively in the interests of raising the level of preparation, training and practice for the personnel. An assessment of the solidity of skills assumes a regard for a whole series of psycho-physiological measures. But each person has his own "norms" for the reaction of functional systems to burdens and other operative factors. This cannot fail to be taken into account when evaluating the operability

and forecasting the reliability of operator labor. It is thus very important to accumulate information on specific individual features of physiological support for the psychic activity of a person.

In the future this will make it possible to compile an "identity card" of the psycho-physiological characteristics and capabilities of a person. Such an "identity card" is necessary to the specialist himself first and foremost. There are large reserves for raising the operability, reliability and vigilance of a person concealed in the use of methods of self-regulation, autotraining, self-monitoring and relaxation. A knowledge of one's own norms makes it possible to evaluate condition, energy and mood more accurately and to implement the necessary corrective influences.

It is also difficult to count on the creation of individually adaptable workstations without an "identity card." Concrete procedures for the automated monitoring of the current state of the operator and the substantiation of effective recommendations to avert erroneous, untimely or non-optimal actions due to the worsening of one's general state are needed for this. There can undoubtedly be no discussion here of some "statistically average" specialist. Individual norms should be taken into account. That is why a database on the general laws of operator activity is essential both for the creation of expert systems in the realm of ergonomics and psychology, and for the assessment of the professional training of specialists.

It is difficult to enumerate all of the tasks and capabilities of the database. But I want to talk especially about one of its functions. The time is passing when aviation physicians, psychologists and ergonomists can be occupied only with "their own" fields. It has turned out that the effectiveness of ergonomic support for the creation and operation of military hardware is closely linked with the training and preparation of specialists and their professional selection, medical support and social amenities in life. Attempts to catch up the socio-psychological and medical support for specialists with the technical support already created not only contradict the systemic approach to design engineering for operator activity, but are also *a priori* doomed to failure. The compensation for ergonomic shortcomings of design and program solutions is reduced by and large to a tightening of the requirements for the physical and psychological status of the specialists. Strict medical and psychological selection of individuals able to adapt themselves better than others to specific working conditions is organized. This rarely leads to the desired result all the same. Such an approach moreover proves to be disadvantageous in an economic regard as well.

That is why, in creating new types of activity including, for example, landing with the aid of an arrester, it is essential to have available, and make skillful use of, data on the general psycho-physiological laws of human activity. Knowing the comparative effectiveness of various ways of psycho-physiological optimization for the flight personnel and the expenditures required to realize them, one may easily conclude that it is more advantageous in many regards to improve the ergonomic characteristics of the hardware and the social and domestic support for the flight personnel than to undertake desperate attempts at intensive training, selection and rehabilitation to compensate for possible psychic and physical overloads. And it is only possible to gather, summarize, make systematic and evaluate ways of raising the reliability of the work of specialists and preserving their health with a regard for intelligent expenditures only on the basis of a database in this case.

The development of special calculation procedures and optimization models will of course be required. But a real opportunity will appear, after all, to eliminate the redundancy that is sometimes encountered in research.

It is time, meanwhile, to put an end to estimating the gains from a database on the person. The time has come to create it.

Description, Analysis of MNF Air Offensive to Open Desert Storm

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[Article by Candidate of Technical Sciences V. Dubrov under the rubric "Aviation in Local Wars": "In Search of New Tactics"; continued from No. 9]

[Text] *According to materials in the foreign press.*

2. Operation Desert Storm

Aircraft of the air forces of the United States, Great Britain and Saudi Arabia subjected military and industrial facilities on the territory of Iraq and Kuwait to massive bombing immediately after a strike by cruise missiles at three in the morning on 17 Jan 91. Aircraft from France and Italy joined them on a second raid three hours after the first one. That is how the operation by the multinational forces (MNF) under the code name of Desert Storm began. Only certain reconnaissance and sabotage groups supporting the success of the aviation took part in it from the ground forces.

The initial stage of the operation, which lasted three days, included 750 aircraft of various types and 52 Tomahawk cruise missiles launched from two American ships in the Persian Gulf.

The cruise missiles went in the first echelon of the operational disposition, and were directed against the most important and heavily protected air-defense assets in the Baghdad region—command-and-control and communications centers, armaments plants and fuel and munitions dumps, as well as air-defense missile systems positions. No supporting measures were carried out before the incursion of the missiles onto Iraqi territory

that could have "awakened" the air-defense system, with the exception of the destruction of several forward-based radars. The MNF command was wagering on complete surprise, which was achieved by the concealed low-altitude flight of the Tomahawk cruise missiles toward their designated targets.

The missile strike that started the mass incursion of the MNF air offensive onto Iraqi territory was a new element in the practices of aerial operations. Manned bombers supported by follow-up reconnaissance, jamming and penetration aircraft used to be employed in the first echelon in local wars before this.

After launch from a ship, the cruise missile headed for the target at an altitude of 50-100 meters at a subsonic speed on the order of 900 km/hr [kilometers/hour] according to a preset program. Control was exercised with the aid of an inertial guidance system corrected at predetermined time intervals according to the relief of the terrain, which ensured the required strike precision (the circular probable error was under 30 meters). The low-signature surface of the Tomahawk (about 0.1 m^2) combined with camouflage against the background of the Earth made their detection by ground radars maximally difficult despite the fact that the Iraqi air defenses were in a state of heightened alert.

The first echelon of the attacking side was not a major group of manned aircraft arranged in a dense battle formation, but rather a stream of hard-to-detect targets dispersed in space at intervals measuring in the tens of kilometers. Whereas the breakthrough had formerly been ensured as the result of the effects of "fire on fire," the method of "infiltration" was selected in this operation, making it possible for the cruise missiles to avoid not only the fire of the air defenses, but also detection by enemy radar.

In the decoy groups coming immediately after the missile strikes, usually justified after the loss of operational surprise, the principal innovation compared to prior operations was the replacement of "provocative" incursions by aircraft and remote-piloted vehicles with the group launch of false targets (FT). The TALD FTs with a mass of 180 kg [kilograms] were employed for the first time. Twenty of them were hung on an aircraft (in place of ordnance) and launched at a calculated point either in a salvo or one-by-one. Each FT simulated the flight of one strike aircraft, with a reflecting surface identical to it. This new style of "decoy" pursued two tactical missions—first, the false incursion would force the enemy radar to come up (the traditional task) and, second, it would give the appearance of a group raid by strike aircraft, force the combat crews of the air-defense systems to decide to fire on them and make use of the situation that was created to penetrate with bombers to the strike targets.

The subsequent stages of the incursion proceeded in a pre-established sequence, but they had also undergone qualitative changes connected with the use of new weapons systems to this or that extent.

The "blinding" stage was the least affected by change, and it proceeded according to the model developed in the course of the El Dorado Canyon operation against Libya. Specialized EF-111 and EA-6B EW aircraft had been brought up, along with E-3A Sentry and E-2C Hawkeye ACP/LRR [airborne command post/long-range radar] systems, even before the start of the operation. They turned on their active jamming systems at the command of the ACP, ensuring the concealed passage of the strike aircraft in the breakthrough corridors that had been created. The first powerful "pulse" was timed to coincide with the cruise missiles reaching their combat heading, and was calculated to neutralize the Iraqi radar before the incursion of the lead strike groups of bombers.

F-15E and Tornado fighter-bombers with the new HARM and ALARM antiradar missiles (ARMs) were used for the first time in the "suppression" stage, along with the F-4C Phantom (Wild Weasel) aircraft. The chief change in the methods of combat application of these specialized systems was the launch of the ARMs from low altitude outside the limits of the lethal zones of the medium-range SAM systems.

An episode with the participation of AH-64 Apache helicopters fell a little outside of the "suppression" stage in time. A squadron of these craft was given the mission of destroying two long-range radars on Iraqi territory two minutes before the start of the incursion by the lead strike groups into the detection zone of the enemy air defenses. A flight of AH-64 Apache helicopters with Hellfire antitank guided missiles (ATGM) was assigned to each target. UH-60 light helicopters were part of the follow-up reconnaissance and cover groups. The flight along the route, laid out with a regard for concealment from Iraqi radar by the terrain, took place at night at low altitude. The helicopter crews used television sighting and navigational systems, as well as night-vision instruments. The target was detected visually at a range of 12 km, and was identified according to external indicators at a range of seven kilometers. The group strike took four minutes—each crew was able to make two passes, employing the ATGMs from a range of 3-6 km. Back-up targets were also hit using non-guided rockets and fire from the 30mm cannons.

The variation with the disabling of long-range radar before the start of the strike by the main forces had already been employed by the Israeli Air Forces in the Lebanese War of 1982. The radar station was destroyed in that case by four F-16 fighters during the daytime.

The stage of employing high-precision (guided) weaponry, called "smart" weapons, had undergone the greatest changes. These, along with F-15E and F-111 fighter-bombers, were employed for the first time on the F-117A Stealth tactical aircraft of the United States (a separate article is proposed to be devoted to that in the

future). The fact that 80 percent of the attacks using "smart" weapons against such important targets as the Ministry of Defense building in Baghdad, command, control and communications centers, fuel and arms dumps and the presidential palace achieved success testifies to the effectiveness of these weapons.

The "group strike" stage using conventional (non-guided) weaponry envisaged the performance of two basic missions—strikes against airfields by British GR-1 Tornado fighter-bombers using JP-233 cluster bombs, and group raids by B-52 strategic bombers.

According to official data, MNF aviation used 88,500 tons of ordnance during the Desert Storm operation, wherein the quantity of high-precision weaponry did not exceed seven percent. The priority of the "smart" bombs, however, cannot be disputed; they hit 30 percent of the overall number of strategically important targets destroyed (not counting the results from the use of the Tomahawk cruise missiles).

The use of the new weaponry at the same time can be delineated, as it were, from the traditional strategy of inspiring fear that was born in World War II and was reinforced after the Vietnam War.

Recall that during the Vietnam War, B-52 heavy bombers made group "carpet" bombings for twelve nights in a row from high altitude during the concluding Linebacker-2 air operation, when one sector of terrain being hit was "superimposed" on another. The "scorched-earth tactics" did not undergo any appreciable changes in the war in the Persian Gulf as well. The strategic bombers covered enormous distances for the sake of this—from bases in England and Spain to the "target area" in Kuwait, and then on to landings at the airfield on the island of Diego Garcia in the Indian Ocean.

The last stage of the air operation was monitoring the results of the strike. The principal burden in this fell to space and strategic reconnaissance. The U-2 and TR-1 aircraft played an important role in the gathering of information after the mass strikes. The drawbacks of these assets for "information-gathering" were distinctly manifested at the same time. They were not able to establish either the numbers or the locations of the Scud mobile missile launchers—which did not cease their firing on important targets in Saudi Arabia and Israel over all 43 days of the war—before the end of the war. The data on the number of Iraqi airfields and radar stations that had been disabled in the course of Desert Storm proved to be clearly overstated. Operations aimed at holding air supremacy continued after the completion of the air offensive operations in this regard. Expensive aviation resources not envisaged by the plan were expended for this purpose.

The results of the aerial reconnaissance were graphically described by a foreign commentator: "Its successes started in places where data was required on stationary targets, and ended in places where immediate information was needed on mobile targets located deep in enemy territory."

The goals of the operation were achieved by the end of two days after it had started, in the evaluation of the MNF command: the command and control of Iraqi aviation and air defenses had been disrupted to the assigned level; aircraft on the ground had been "neutralized" after the damaging of runways and taxiways at airfields; the opposition of Iraqi fighters had been almost entirely eliminated; medium-range SAM systems had been disabled, which later made it possible to carry out raids at safe altitudes outside the ranges of air-defense missile systems and anti-aircraft artillery (23mm mobile mounts).

MNF aviation made 2,200 sorties over this period, subjecting more than 60 important ground targets on Iraqi and Kuwaiti territory to attack. The losses were four aircraft for the United States (one F-15 and F-18, and two A-6s), two Tornado aircraft for the British Air Force, one Tornado for the Italian Air Force and one A-4 aircraft for the Kuwaiti Air Force. Four French Jaguars were moreover damaged from cannon fire from field air-defense systems. Some 76 MNF aircraft and helicopters were lost in all over the Desert Storm operation, of which the combat losses totaled 42 (an average of one a day).

The stage of battlefield air interdiction that started after the winning of air superiority lasted more than a month, until February 24. It was typified by operations against targets among the Iraqi troops on defense and the destruction of lines of communication linking the troops with supply bases. A significant share of the resources, as has been noted, was expended to maintain the "supremacy" already won. The ground offensive began only after thirty eight days, supported by aircraft and helicopters from all branches of the armed forces in the anti-Iraqi coalition. This operation received the name of Desert Sword.

(Continuation to follow)

Variations in Pilot Ability to Fly at Minimums Analyzed

92UM0465G Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 10, Oct 91 (signed to press 19 Sep 91) pp 28-29

[Article by Military Pilot 1st Class Colonel V. Skrynnik under the rubric "For the Arsenal of the Military Pilot": "Each Has His Own 'Minimum'"]

[Text] I know from my own experience that an instrument landing approach is a complex and most crucial stage of the flight, and requires the particular concentration of the pilot's attention on piloting the aircraft and excessive nervous and emotional stress.

There is no doubt that the piloting and navigational equipment of modern aviation systems and ground electronic gear makes it possible to perform a landing approach under the harshest of weather conditions. The capabilities of the hardware, however, are ultimately realized by a person. The wholly natural question thus arises of whether all pilots are able to fly at the landing and takeoff minimums stipulated for a specific type of aircraft.

Practice shows that the answer is no, far from all. Each pilot has his own "minimum," and it is determined by a number of factors; the solidity of the skills acquired by the crew commander when performing flights under bad weather conditions, for example, the "cleanness" of his piloting when transferring from instrument flight to visual etc.

An instructor who ascertains errors in piloting technique being checked in a performance-graded flight often faces a choice—continue the dual-instruction program, or permit the pilot to make solo flights but under less difficult weather conditions. Here the instructor must display wisdom, since the later flight career of his subordinate will depend largely on his decision. If he grounds the pilot, he could develop a lack of confidence in himself over time due to his failure.

But what if he lets the pilot fly anyway? Under just what specific weather conditions, then? And on what will he base his decision? On personal experience? But it is not enough, after all, to count just on one's own intuition...

I propose the use of nomograms (see figure) to best substantiate the establishment of values for the cloud base H_{cb} and the range of landing visibility D_v at which a pilot will be able to complete a flight assignment successfully.

The maximum deviations of the aircraft from the assigned trajectory by heading ΔK and by altitude ΔH and errors in maintaining the assigned rate of descent ΔV were selected as the initial data for performing the calculations.

During a landing approach using an RMS [radio-beacon landing system], D_v is determined according to the formula

$$D_v = D_{v\Delta K} + \Delta D_{v\Delta H} + \Delta D_{vtk},$$

where $D_{v\Delta K}$, $\Delta D_{v\Delta H}$ and ΔD_{vtk} are the distance covered by the aircraft over the time the pilot eliminates errors in the direction of approach and in altitude, as well as over the time that passed from the time he established visual contact with the runway (or point of reference) to the moment of the start of correction of those mistakes.

Under conditions where the landing approach is being made using OSP [instrument landing equipment] with an RSP [radar landing system], the initial formula takes the form

$$D_v = D_{v\Delta K} + \Delta D_{v\Delta H} + \Delta D_{vtz} + \Delta D_{vtk},$$

where ΔD_{vtz} is the distance covered by the aircraft over the time necessary for the automatic resetting of the ADF to the operating frequency of the BPRM [middle compass locator].

In both cases the calculation of H_{cb} is performed according to the formula

$$H_{cb} = D_v \sin\alpha_g,$$

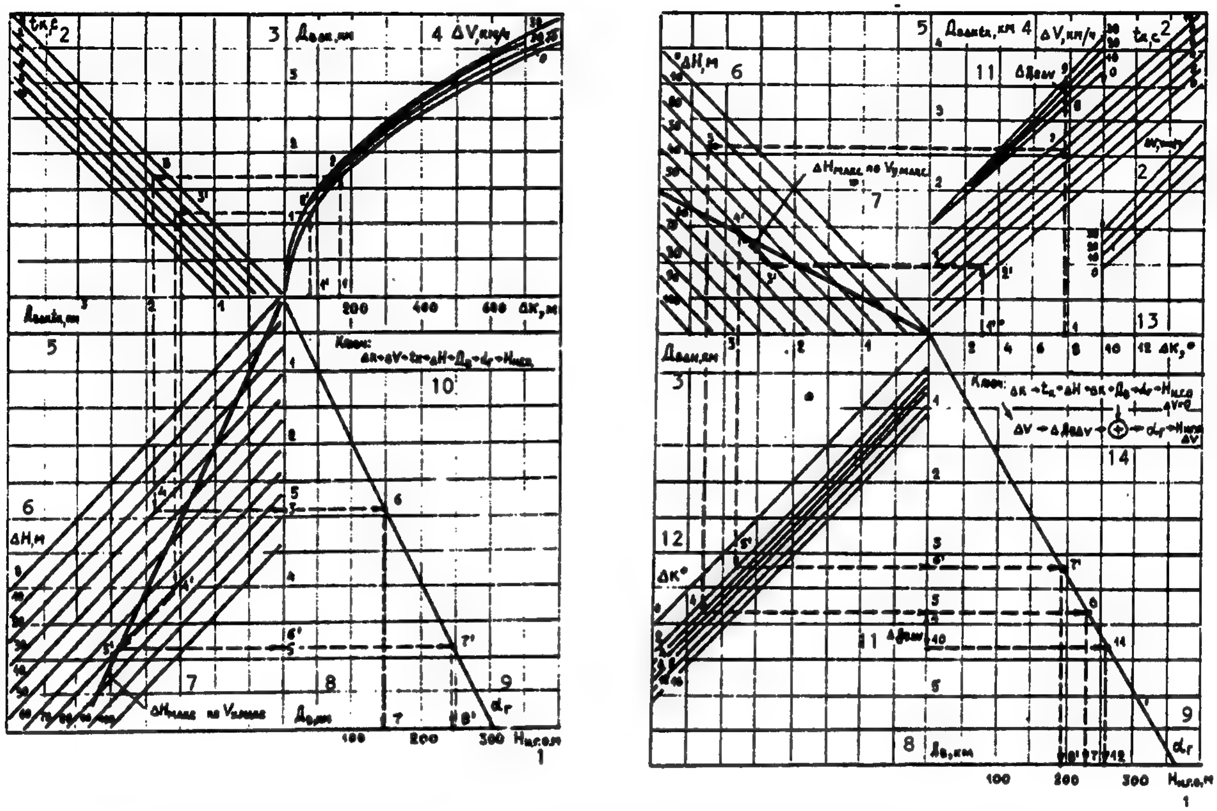
where α_g is the angle of inclination of the glide path.

We will determine according to the nomogram, as an example, the unknown values for D_v and H_{cb} in a landing approach using an RMS. We will say that the pilot error in maintaining the direction of approach was 180 meters by the time of establishment of visual contact with the runway (as determined by the instructor according to the glide slope deviation of the NPP or by report from the operations officer of the landing zone). We move vertically from that value on the X-axis up to an intersection with the curve constituting ΔV. Next, allowing for the time expended by the pilot in eliminating all of the errors he has made and making the decision to carry out the landing (this is also determined by the instructor), we obtain the result $D_v = 2.8$ km and $H_{cb} = 150$ meters.

The automatic mode of aircraft control is considered to be the principal one in flight practice when making a landing approach in bad weather conditions. Taking into account the complexity of switching from instrument flying to visual, however, the instructor should determine the cloud base and the landing visibility for future flights by the trainee according to the results of approach in manual control mode. It should be remembered herein that the minimal values of these parameters should fully ensure safety in the concluding stages of performance of the assignment—the pilot should have sufficient time available to establish reliable contact with the ground, correct the flight trajectory and make the final decision to perform the landing after the moment of the emergence of the aircraft from the clouds (entry into range of visibility).

If the trainee is able to eliminate the deviations and get onto the runway alignment area before the moment of the start of roundout under the given weather conditions without exceeding the maneuver parameters allowable for that stage of the flight (degree of slip no more than 15°, increase in vertical velocity no more than 2-3 meters/second), the instructor then has the right to decide to permit him to make a solo landing (the established values of H_{cb} and D_v should correspond to the conditions under which the training is being conducted). The indicated parameters should otherwise be increased in proportion to the time of delay in the pilot's making of the decision to execute the landing.

These recommendations would seem to be able to help instructor pilots in evaluating the readiness of fliers for solo flights under landing and takeoff minimums.



Nomograms to determine the minimum values of landing visibility and cloud base depending on pilot errors in the landing approach (V_{avg} = *375 km/hr*) on SMU using RMS and OSP with RSP

Key:
1. H_{cb}, meters
2. tk, sec
3. $D_{v\Delta K}$
4. ΔV, km/hr
5. $D_{v\Delta Ktk}$, km^3
6. ΔH, meters
7. ΔH_{max} for $V_{y/max}$
8. D_v, km
9. α_g
10. Key: ΔK— ΔV— tk— ΔH— D_v— α_g— H_{cb}
11. $\Delta D_{v\Delta V}$
12. $\Delta K°$
13. $\Delta K_2°$
14. Key: ΔK— t_k— ΔH— ΔK— α_g— $H_{cb,\ \Delta V\ =\ 0}$;— ΔV— $\Delta_{v\Delta V}$— + (D_v)— α_g— H_{cb}, ΔV

Faulty Instrument Readings Said to Cause Erroneous Flight Actions

92UM0465H Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 10, Oct 91 (signed to press 19 Sep 91) p 30

[Article by Colonel V. Barachenkov under the rubric "Flight Safety: A Special Case": "The Tragedy Could Have Been Averted"]

[Text] The flight shift started off as usual on that ill-fated day. The weather reconnaissance data confirmed the possibility of flights under the basic version of the operations schedule. The aviation hardware, manpower and support and control equipment were ready for the flights, according to the reports of the subunit commanders and service chiefs.

The flight commander, a military pilot 1st class, was to take up a MiG-25 RB for a post-maintenance flight check after the replacement of an engine and 24-month

tuning and adjustment. He had already performed similar assignments, and thus felt confident. However...

The pilot, in the 21st minute of the flight and at an altitude of 16,000 meters, before turning off the afterburners, felt a powerful shaking. Later, in descent, he reported, "...it won't go... I don't know what happened... the stick is all the way forward... I am going only on afterburner... I turn off the afterburner, and the speed 'settles down' momentarily."

The pilot had to turn on the afterburner repeatedly to maintain the assigned speed according to the instruments during the descent stage. The fuel reserves were expended as a result. It became impossible to land at his own airfield.

The pilot ejected by order of the flight operations officer. This was done at a speed that exceeded the allowable one for abandoning the aircraft. The pilot was killed.

What could have happened on board the aircraft so that it was only possible to maintain a speed close to the assigned one in descent using the afterburners? Many contradictory versions arose. If the engines were not creating the necessary thrust, as the pilot reported, then it was not needed in descent anyway. A descent from an altitude of 15,500 meters is made with the RUDs [thrust levers] set at the idle stops, according to the RLE [flight operations manual]. If there were resistance forces, then from what? The opening of the speed brakes in a descent will not lead to a drop in the indicated airspeed in the "Maximum" mode at the vertical speed of 40 m/sec. If there had been destruction of the airframe structure, the area of resistance should have exceeded the area of the speed brakes even in a qualitative evaluation. But even if that had happened, why were aircraft controllability and stability maintained, and why didn't additional aerodynamic moments arise? Was the system for measuring speed itself in good working order?

It was namely these questions that faced the members of the commission investigating the flight mishap. The magnitude of the speed could have been determined with a sufficient degree of precision at the CP [command post] using the data from radar tracking. The commission established that this had not been done, however, due to the poor training of the GRP [flight-operations group] personnel and the RP [flight-operations officer] himself, as well as due to the large number of flights planned at low altitude and ceiling at the start of the flight shift (aviation hardware flight checks) for electronic reconnaissance. All of this exceeded the capabilities of radar monitoring: the RP, distracted by the flight of a reconnaissance aircraft close to the prohibited zone, intervened in the control too late, while the officer on combat command and control at the CP did not switch the pilot over to the tower frequency, *i.e.* effectively no help came.

It was established in the course of further investigation that there had been a breach of the seal of the main lines of the full and static pressure lines of the PVD [pitot-static head] system in flight. This led to the understating of the indicated airspeed, which the pilot took as a drop in thrust, while the shaking that he reported was the movement of the aircraft into the "Vortex sheet" mode. And later, evidently assuming that the destruction of the power plant or the airframe structure had occurred, he focused his attention on seeking a solution to get out of that dangerous situation. The pilot had lost sight of the chief fact therein—the failure of the speed readings to conform to the operating mode of the engines was the first sign of PVD failure. He also made no attempts to analyze the readings of other instruments, even though there was still an opportunity to do so.

Much of the situation described will probably seem a simple and obvious special case in flight, but there are seemingly clear-cut recommendations for it as well. One can cite more than one instance, however, where emergency situations with grave consequences arose due to failures of aneroid/membrane instruments (AMP) and their late recognition by the pilot or crew. It must be noted herein that experienced pilots were doing the flying in many cases.

The conclusion that could be drawn is unequivocal—all is not well with the ability of flight crews to determine such failures. The reasons could be various ones: poor simulator training, unclear recommendations as set forth in the RLE for determining the indications of such failures, or the poor knowledge of the designs of the PVD and AMP systems on the part of the pilot.

The flight crew must remember that in the event of a special situation, they must analyze the readings of various instruments in as detailed a manner as possible, and associate the information obtained with flight parameters whose correctness evokes no doubts in order to make the correct decision. In the case described, it would have been enough for the pilot to look at the readings of the automatic control adjustment system, and he would have noticed the discrepancy in their readings with the flight speed.

Another example. A pilot making a horizontal flight by instruments on an Su-17 M4R tried for several minutes to alter the engine operating mode to maintain the assigned true speed, which had increased for reasons incomprehensible to him (as was later established, as a consequence of the clogging of the PVD static main line and the smooth drop in flight altitude). The aircraft stalled as the result of throttling the engine all the way back to idle. The pilot ejected. Had he been able to evaluate the readings of speed and angle of attack correctly and analyze the reasons for changes in them, the aircraft would not have been lost.

What must be undertaken to rule out similar situations? First and foremost, it is essential to improve technical training radically. It would be expedient for IAS [aviation engineering service] specialists, when conducting classes with the flight personnel to study the design and

specific features of AMP operation, to "game out" various versions of possible failures, paying attention therein to their typical indications and methods of detecting them. The methodological scholars at the centers for the combat application and retraining of flight personnel should be concerned about whether the RLE and methodological texts spell out how to recognize a failure, how to act in such a situation, and whether the training, simulations and simulator checkups envisage them to the full.

It is especially important to teach the skills of "filtering" doubtful information, establishing objective parameters and making the optimal decisions to both crews and to specialists in the flight operations groups.

Positive results can be achieved, in the opinion of the leaders of the Aviation Flight Safety Service of the USSR Ministry of Defense, only through the joint efforts of all fliers, staff members at NIIs [scientific-research institutes], testers and officers in the line units. Only with such interaction can dangerous factors be revealed.

History of Development, Launches of First Satellites Described

92UM0465I Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 10, Oct 91 (signed to press 19 Sep 91) pp 37-39

[Article by Yu. Biryukov under the rubric "From the History of Space Science": "The Price of Decision—First Place (The First Satellites)"]

[Text] The possibility of putting a projectile reaching the necessary velocity (for the Earth, about eight km/sec [kilometers/second]) into orbit around the planet was substantiated as early as by Newton in 1687. This possibility attracted the attention only of the authors of textbooks on celestial mechanics illustrating the law of universal gravitational attraction—as well as ballistics, showing the theoretically unrestricted increase in firing range with increases in the initial velocity of the projectile—for roughly two centuries.

Only Tsiolkovskiy ascertained the expediency of creating an artificial Earth satellite. He wrote in 1895 in his short science-fiction novel with a predominance of elements of the popularization of science, "Reveries on the Earth and the Heavens," that "An imaginary satellite of the Earth, like the moon, but arbitrarily closer to our planet, only outside the limits of its atmosphere (this means about 300 versts from its surface) represents, with a very small mass, an example of an environment free of gravity." Many years of reflection on outer space as a beneficial environment for the habitation of man in the future and his calculations led him in 1898 to discover a real method of achieving escape velocities using a liquid-fueled rocket. Only five years later Tsiolkovskiy published the seminal work "Researching World Spaces Using Jet Instruments," transforming dreams of flights in space into a promising direction of scientific theory.

Only at the beginning of the 1950s, when as a result of successes in rocket building the practical possibility of achieving cosmic velocities was achieved, was the concept of a small automatic research satellite born and developed in parallel and effectively independently, albeit taking different paths, in the USSR and the United States. The American satellite launch program became known before ours. True, both were preceded by a British proposal to create a minimal satellite apparatus that was read in 1951 at the International Astronautical Conference, but it did not receive state support, insofar as England was not seriously engaged in the development of its own rocket building at that time.

Research of the upper layers of the atmosphere and cosmic rays with the aid of ballistic rockets developed on the basis of captured German V-2 (A-4) rockets in the United States in 1946 and the USSR in 1947 was direct preparation for the creation of satellites. The Americans, who had gotten over a hundred such rockets, launched them over the course of five years without being in any hurry to develop their own special Viking geophysical rockets. The latter were more advanced than the A-4 but had a much smaller payload capacity and, most importantly, were manufactured in single copies, and were thus exceedingly expensive and unreliable. Soviet specialists were able to assemble just ten A-4 rockets from the captured parts and assemblies, but they had already assimilated their own production of similar items—the R-1—starting in 1948. Starting in 1949, when the launches of the R-1A rockets on a vertical trajectory began, more and more powerful and improved series-produced combat missiles with the appropriate refinements began to be used as geophysical rockets, which was much cheaper and more reliable. Apparatus for researching cosmic rays, solar radiation, electromagnetic fields, the parameters of the upper atmosphere and the cloud cover of the Earth, as well as for biological experiments that could be employed in satellites had effectively been prepared in both the USSR and the United States in the launches of the high-altitude rockets. American scientists, however, had to devote much more attention to miniaturization and reliability testing of their research apparatus due to the small capacity of the launch vehicles. These differences had an immediate impact on the choice of the type of launch vehicle (LV) and the initial designs of the satellite when the issue of creating the first satellites arose, and they were reflected in the terminology—they were creating minimal satellites, and we were creating the "simplest."

The first engineering design in America for the launch of the small Orbiter satellite—if one does not count projects of an evaluative nature that from the Rand Corporation—was developed jointly by the Army Ballistic Missiles Agency, the Naval Research Department and the industrial firm of Aerojet General. The use of the tested Redstone military ballistic missile based on the A-4 under the leadership of W. von Braun was its

foundation. The upper stages were proposed to be assembled from reliable solid-fuel Lucky missiles. This launch vehicle, which received the name of Yunona, would have been able to put a payload of up to seven kilograms [kg] into orbit. The Orbiter project, however, was buried due in particular to the fact that many did not like the leading role played in it by former German specialists, who had still not received full citizenship in the United States. This decision, as it later proved, cost the United States first place.

A widely broadcast presentation of the first design for an American satellite that had been adopted for implementation by the forces of the U.S. Navy now took place on 9 Sep 55. A modified version of the Viking was utilized for the first stage of the LV, an improved Aerobee meteorological rocket for the second stage and a specially designed solid-fuel rocket engine for the third stage. The rocket was able to put just 10 kg of payload into space. Only a radio transmitter and a solar cell to power it were installed in the gilded body of the first satellite. Its mass was brought to 1.5 thereby. The project nonetheless received the proud name of Vanguard.

The American scientists and President D. Eisenhower supporting them, after all, were confident that only a very rich country such as America was able to do mankind the great favor of of such an outstanding experiment. The impending satellite launch was widely proclaimed as the central event of International Geophysical Year (IGY) starting 1 Jul 57.

It could be noted that a detailed development of a minimal artificial object already existed in the United States by this time, designed and manufactured by Professor S. Zinger of the University of Maryland, who had named his creation the "Minimal Orbital Unmanned Satellite of the Earth," which as abbreviated produced the English word Mouse. But no matter how much the professor tried to miniaturize the entire apparatus, his "mouse" still weighed 45 kg and was not suited for launching into space; the principles inherent in it, however, were utilized on other satellites.

Research in the realm of space science was underway in the Soviet Union, inseparably linked with the state rocket-building program. More and more powerful rockets were being created at the OKB [Experimental Design Bureau] of the pilot industrial scientific-research institute NII-88 [Scientific-Research Institute 88] under the leadership of S. Korolev, while they were studying the possibility of using them for researching space at NII-4 of the Ministry of Defense under M. Tikhonravov. We had already studied quite deeply the basic issues of launch theory, orbital flight and descent to Earth, as well as possible realms of application of the simplest satellites, by the time the decree appeared on the creation of the R-7 intercontinental ballistic missile (ICBM) in 1954. The government decided in May of that same year, by request of S. Korolev, to create a satellite launched with the aid of an ICBM in this regard. This immediately gave Soviet designers the opportunity of carrying out design studies for satellites hundreds of times larger in mass than were being planned in the United States.

Specialists estimated that a booster rocket created on the basis of the two-stage R-7 would be able to put a payload of 1.3-1.4 tons into orbit. It was namely for that payload that the first artificial satellite program in the USSR, with the name of Object D, was developed at Korolev's OKB in Department No. 9 for the development of space vehicles, which was headed by M. Tikhonravov. It was being developed in several versions that were distinguished by the composition of the scientific apparatus, and was an exceedingly complex—albeit not orientable in flight—space vehicle with an airtight body. It included a power-supply system with solar and chemical batteries, thermal regulation using a system of louvers on the outside of the spacecraft and fans inside it and radio communications with multichannel apparatus transmitting telemetric data and receiving commands from the ground, as well as switching and program-recording devices. Three quarters of the mass of the satellite went for the scientific and measuring apparatus. The installation of a cockpit for an experimental animal to replace some of the apparatus was planned in one of the versions.

By September of 1956, while Korolev was defending the preliminary design for this satellite before an interagency commission chaired by M. Keldysh, work on its creation was launched on a broad front and proceeded successfully, by and large. The developers foresaw no particular difficulties in its development even though the apparatus was being designed for prolonged presence under weightless conditions in outer space for the first time.

There were many more problems with the launch vehicle. They had to reach a level of perfection in the design of the body, engines and control system that was at the limits of engineering capabilities at that time in order to obtain the necessary characteristics. The work thus proceeded well behind the planning deadlines, so that it was to go for flight testing only in March of 1957. It was very vexing for the Soviet Union, which then had such an obvious advantage in rocket building, to cede first place. It must be taken into account that the Soviet participants in the latest International Astrophysical Congress in the fall of 1956 had quite definitely, albeit modestly, reported the intentions of the USSR to launch its own satellites under the IGY program, and moreover of much greater mass than that announced by the Americans. This announcement, like a series of subsequent ones where radio enthusiasts around the world were given frequencies to receive the signals of Soviet satellites, it is true, was received with great skepticism by the world community. This is understandable—specialists and the press in the United States were not bashful in describing the grandiose difficulties and complexities of the problems that had to be overcome for the launch of even a minute satellite.

Korolev understood the worldwide historical significance of the very fact itself of the flight of the first

artificial heavenly body. That is why he, even before the start of testing of the R-7, decided to retreat to a minimal, very simple satellite, called the PS-1, that would just circle the Earth and let the whole world hear its voice. In order to guarantee being the first, he proposed launching such an apparatus during the process of testing the "seven" even before the start of the IGY in April-June 1957. But they were unable to do this, owing to the faulty outcomes of practice flights that started only in May of 1957.

The rocket was very complex for the times—five units located in parallel with 32 simultaneously firing liquid-fueled engines; 12 of those swiveled on their supports to ensure control of the flight of this unstable system, inclined to wobble. It is not surprising that everyone aside from its creators had doubts about the possibility of rapid development and the achievement of high reliability. Therefore the design bureau headed by M. Yangel was entrusted with evaluating the possibility of the immediate launch of a similar satellite using the simplest of booster rockets based on the strategic R-12 missile, which had successfully completed flight tests at that time, simultaneously with the acceptance of the Korolev proposal to launch the simplest of satellites during the R-7 tests. Analysis showed that this task could be accomplished, but it would scarcely have been accomplished any faster than Korolev or the Americans. And Yangel in reality supported the creation of the light-class Kosmos launch vehicle five years later. But that was not "improvised," but was rather at the most serious scientific and technical level.

The Americans launched the Redstone in the summer of 1957 with clusters of several small powder rockets installed on it, achieving a range of more than four thousand kilometers. But our "seven" was successfully launched on August 21, flying about 5,600 km from Baikonur to Kamchatka. Specialists abroad understood that this was a serious claim to first place in the launching of an artificial satellite. This flight was for some reason not a sensation for the broad masses and the press, however. And when on 19 Sep 57, on the 100th anniversary of the birth of K.E. Tsiolkovskiy, Korolev announced outright that the first test launches of artificial Earth satellites would be made in both the USSR and the United States in the near future, this was perceived as the report of a fundamental capability rather than concrete preparations for launches. This in any case in no way lessened the sensation with which the TASS report of the flight of the PS-1 was received around the world.

The world now understood, in the first hours after the report, that civilization had reached a qualitatively new level in the mastery of space from that day forward, and that the entire history of world humanity had been divided into the era before Sputnik and after Sputnik. It was thus, without quotation marks and with a capital letter, that journalists around the world began writing the word, and it was clear to all that the discussion in this case concerned a great event that had occurred on October 4, 1957. Ten years later this day was legally affirmed as the day of the beginning of the Space Age of mankind by decree of a congress of the International Astrophysical Federation.

Returning the victor to Moscow, Korolev heard from N.S. Khrushchev a desire to commemorate the 40th anniversary of Great October with a similar launch, so that it would be clear to the world that this success was not a chance event for us, but rather the result of the systematic scientific and technical policy of a socialist state. The launch of Object D could unfortunately not yet be made due to the lack of preparedness of the complex scientific apparatus, but Korolev did not want to repeat the flight of the PS-1 in its prior form. And even though he had less than a month at his disposal, he resolved on a surprisingly daring step—to create the first biological satellite, the PS-2, over that brief period of time. The question of whether a higher-order being could preserve its viability under conditions of prolonged weightlessness, after all, had now become the most interesting one for space-science enthusiasts around the world. The strategy for the mastery of space depended markedly on the answer to it.

A unique technical operation was thus launched at Korolev's enterprise starting on October 10. The design for an unprecedented apparatus with a pressurized cabin, life-support systems, thermal regulation, radio communications and telemetry was created without preliminary or engineering designs, using rough calculations and sketches done by hand and without long coordinating sessions. The satellite was developed and manufactured in roughly two weeks. The transmission of data on the principal vital functions of the first space passenger was envisaged, and that passenger went into history as the little mongrel dog Laika. The refined PS-1 also included, aside from the cabin for the animal, a spectrograph for researching the ultraviolet and X-ray emissions of the sun.

The world was struck by a new sensation—the first living being was in orbit, and the mass of the satellite was also more than half a ton. It was namely that value that surprised both specialists and non-specialists the most at the time, but now they are more surprised by the rate at which this space vehicle, which entered history as the first biosatellite, was made and launched.

The only thing that reflected the haste was the lack of actuation and failure of the system to separate the satellite from the central unit of the booster rocket after its entry into orbit. This caused a disruption of the thermal regimen in the cabin, and Laika experienced tropical heat for the greater portion of the seven-day experiment. Her return to Earth was impossible at that time. This sacrifice on the altar of science, however, provided the opportunity to prepare for the flight of a person into space.

And what of the Vanguard? Its launch, announced for October 1957, had been postponed several times and, finally, organized as a grandiose show with a great crowd

of people, culminating in a striking explosion on 6 Dec 57. The Americans then had to accept a proposal to make the launch of their own first satellite using—rather than the Vanguard booster—a system developed at the U.S. Army Redstone Arsenal under the leadership of W. von Braun. Even though this was offensive to the nationalist feelings of the Yankees, one could ignore that compared to the harm to the national prestige of the United States that was inflicted by the failures of the Vanguard. The Braun team prepared their own Yunona-1 launch vehicle, named the Jupiter-C, for launch over two months.

Its first stage was a Redstone rocket that had been converted from an alcohol-oxygen fuel to a more efficient kerosene-oxygen fuel. It was thus possible to employ more powerful Sergeant rockets in the upper stages in place of the planned Lucky. The second stage was 11 solid-propellant Sergeant rockets arranged in a circle, inside of which was the third stage composed of three of the same rockets, with the fourth stage—one more Sergeant rocket with the satellite, which received the name of Explorer—on top of those. Even though the mass of the satellite was just 14 kg, a Geiger-Müller counter had been installed on it for the first time at the suggestion of Iowa University physicist J. Van Allen.

The Explorer-1 began transmitting valuable information on the radiation situation in its trajectory immediately after its successful launch on 1 Feb 58, information which Van Allen was able to evaluate quickly, expressing the hypothesis of the existence of a radiation belt around the Earth. Our scientists, who had similar information from the instruments of the PS-2, had been a little more circumspect in their interpretations and thereby ceded one of the most brilliant discoveries of the start of the Space Age.

The Vanguard suffered its next catastrophe on 5 Feb 58, but got into orbit on March 3 nonetheless. The greatest impression on the world that year, however, was made by the launch of Object D on its second attempt on May 15 (in the first, on 27 Apr 58, resonant frequencies had destroyed the launch vehicle even before the separation of the stages), becoming the third Soviet satellite. This was a veritable factory of most valuable scientific information on the processes and phenomena transpiring in near-Earth space, the amount of which surpassed all of the conceivable records up to then for the "productivity" of any of the research devices that had been created by that time.

Near the end of the year the Americans, taking our path of using military missiles for space purposes, launched into orbit their own Atlas ICBM that had undergone flight testing, with an instrument compartment containing 68 kg of SCORE apparatus (an acronym signifying an experiment on the orbital relay of communications signals). This flight naturally elicited great interest among specialists, insofar as the prospects for using artificial satellites for communications and television had now been widely recognized around the world.

Survey of History, Achievements of Soviet Space Program

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[Article by Doctor of Technical Sciences V. Senkevich and Candidate of Technical Sciences A. Voytsekhovskiy: "The Evolution of Potential—*Toward the Launch of the First Artificial Earth Satellite*"]

[Text] The launch of the first artificial object onto space on 4 Oct 57 had an impact that had not been produced by any scientific and technical achievement before. It was that event that became the beginning of the space age.

More than three decades have passed since that time. Over that historically brief time interval space science, which has developed at a surprisingly rapid pace and been transformed into an important sector of the national economy, has solidly entered our lives as a means not only of studying the universe, but also of accomplishing vital "Earth" tasks. The United States, France, Japan and China have followed the Soviet Union on the road into space with the aid of their own launch vehicles. Today more than 130 countries of the world take part either directly or indirectly in space operations, and utilize the information from satellites and orbital stations to accomplish diverse tasks.

This activity was accomplished in the USSR in accordance with a State Program designed for a prolonged period. Each stage of it (the launch of the first Earth satellite, for example, the first cosmonaut, the extravehicular activity of a person in open space, the achievement of escape velocity, thanks to which flights of craft to the moon, Venus and Mars became possible) are all major steps in the assimilation of outer space and an enormous contribution to world science. The best argument is numbers. So then, of the 40 first and highest-priority achievements in space science in the solution of scientific and national-economic problems, 23 belong to the Soviet Union and 17 to the United States of America. The USSR and the United States are thus by rights considered to be the leading space powers.

The majority of the Soviet people experience a feeling of pride for the historic achievements of Soviet space science, and have a high regard for its contribution to scientific, technical and social progress and the building of our common space home.

We also have a respectful attitude, at the same time, toward the achievements of all other countries in the world assimilation of space and are proposing and realizing joint programs, although it must be acknowledged that only a very little has yet been done in that direction.

Today we possess mighty rocket and space hardware and ground support systems and equipment, and we have created several types of launch vehicles—from the Sputnik and the Vostok to the heavy Proton and the superheavy Energiya. Three cosmodromes have been built, control centers exist for flights by automatic and manned spacecraft (the Flight Control Center at Kaliningrad in Moscow Oblast, the Long-Range Space Communications Center near Yevpatoriya and a multitude of regional centers and receiving stations for national-economic and scientific information from spacecraft), a far-flung network of ground and ship stations for communications and the receipt of telemetric information in the structure of the command and measurement control complex. Dozens of types of automatic and manned space vehicles for various dedicated purposes have been launched into outer space.

The necessary scientific-production and experimental base equipped with modern equipment was created for scientific-research, design, planning, testing and other types of operations. Supervision of the principal developments was exercised by the USSR Ministry of General Machine Building in close interaction with the client agencies and allied ministries and co-executor agencies. The total expenditures for all the years of the space era are very large. Tens of billions. And the return? It is also large. But it could be even larger. It is commonly acknowledged today that space science has largely become an economically efficient sector of the national economy.

The development of space hardware and the research and assimilation of outer space are one of the characteristic and important directions for contemporary scientific and technical revolution. The development and creation of space and rocket systems that are varied in purpose and design and can function for a long time in space, including artificial Earth satellites, manned spacecraft and interplanetary automatic stations, have accelerated the development of some scientific and technical spheres. Progress in space science has thus played an appreciable role in improving electronics and computer technology, power engineering and machine building, chemistry and many other sectors of industry. Space science, with its unprecedentedly high requirements for information content and operating life, reliability of systems and assemblies, micro-miniaturization and reductions in mass and dimensions is providing an impetus for those sectors today to reach levels that they had not reached yesterday, forcing the utilization of the latest achievements, the improvement of technology and the modernization of production.

Space science has posed a number of complex problems to applied science as well. Their solution ensures progress in materials science, the technology for machining metals, power engineering, aerodynamics and the creation of automatic control systems, among others.

A prospective program for the creation of space hardware for national-economic and scientific purposes for the period to the year 2005 (Program-2005) has been developed and submitted for the consideration of the USSR Supreme Soviet and the public in order to organize comprehensive planning activity.

The range of items of space and rocket hardware that is currently being developed and produced is exceedingly broad. Space apparatus for national-economic purposes should be noted here first and foremost.

Satellites of the Resurs, Okean and Meteor types are used for ecological monitoring of the environment, research of the natural resources of the Earth, geodesy and hydrometeorology. Analogous tasks are being performed today by the Gorizont and Ekran satellites along with variations of them, as well as the modern Ekspress, Mayak (Marafon system), Galo and Gelikon. They have increased throughput capacity and made it possible to organize communications with moving objects and encompass the entire population of the country, including in the republics, with multichannel television broadcasting. The creation of a universal space information platform placed in geostationary orbit by the Energiya launch vehicle lies in the future. Satellites of the Nadezhda (Tsikada) and Glonass types are a means of navigation, search and rescue and mobile communications.

The production in space of materials with improved properties is supported with the aid of Foton satellites and the Kristall module as part of the Mir orbital station.

Space research enriches us with discoveries and new scientific results. Extensive experimental material on near-Earth space, the moon and the planets and processes transpiring in the atmosphere of the Earth, on the sun and the structure of matter has been obtained thanks to it. These new facts clarify substantially, and sometimes radically alter, ideas about the world around us.

The moon is becoming the object of systematic study with the aid of various space vehicles, both Soviet and American, with the development of space science. Some 24 stations of the Luna series and five automatic Zond series stations have been launched in the USSR. Research has shown that despite the fact that the ages of the moon and the Earth are commensurate and the distance between them is negligible in astronomical terms, the differences in their structure and evolution are exceedingly substantial.

Our ideas about the planet Mars, studied by Soviet and American automatic interplanetary stations, has also been fundamentally altered. We have sent a total of ten automatic craft of the Mars, Zond and Fobos types to the planet Mars and its satellite Phobos.

World science has obtained much new data as the result of flights of Soviet and American stations to Venus. First place in the study of this plant belongs to the USSR. Some 16 automatic stations of the Venera type and two craft in the Vega series have been launched. The Venera 1-8 spacecraft entered the atmosphere of the planet

themselves, while the Venera 9-14 craft separated into orbital sections and descent modules and the Venera 1-16 were satellites of the planet and performed radio soundings of it.

Space research of the moon, Venus and Mars was the foundation for the development of the new science of comparative planetology, which has facilitated an understanding of processes transpiring on the Earth.

The launch of the Vega-1 and Vega-2 automatic craft in December of 1984 and their flights to encounter the comet Galileo on 6 and 9 March 1986 were the first steps in the study of the small heavenly bodies of the solar system with the aid of space hardware.

Manned flights occupy a special place in the Soviet space program. Since the time of the first flight by Yu. Gagarin, more than 250 emissaries of the Earth from 20 countries have visited space, with 70 of our countrymen among them. A crew of Soviet cosmonauts including V. Titov and M. Manarov brought the length of stays in space to one year.

The achievements of Soviet space science in the Vostok, Voskhod and Soyuz manned programs allowed our country to create several generations of long-term stations starting in the 1970s, from the single-unit Salyut (1971) to the more powerful and multi-unit Salyut-6 (starting in 1977) and Salyut-7 (1982) stations, finally reaching a virtually permanently operating structure in space with six docking assemblies—the Mir station (1986)—serviced by manned craft: first the Soyuz (starting in 1971) and Soyuz T (starting in 1980), and now the Soyuz TM (as of 1987) and the Progress series cargo craft (as of 1978). Some of the manned craft of the Soyuz and Soyuz TM types were also operated in unmanned versions.

The orbital stations are able to function reliably for many years in near-Earth space, successfully performing the planned program of operations therein, the principal areas of which are the comprehensive study of the natural resources of the Earth and mapping (we would note that it is possible to photograph territory from orbit in five minutes with the required resolution whose photographing from an aircraft would require 1.5-2 years of flight work), study of the Earth's atmosphere, research of various physical phenomena and processes in outer space, astronomical, medical and biological research, the run-through of new on-board systems and instruments, experiments and semi-industrial operations in space technology and materials science.

The technical and technological experience in organizing the management of complex projects and developments in space science is finding widespread application in other sectors of the national economy as well. More than 240 new technological processes, 130 types of equipment and more than 100 new materials were developed in the creation of the reusable Buran spacecraft and the super-heavy Energiya launch vehicle that could also find, and are also finding, application in aviation, shipbuilding, the nuclear, light, chemical and radio industries and in medicine.

That is inadequate today, however. The United States, for example, has a considerably greater economic return from the creation of space hardware. It is well known that the American space industry, which spent approximately 25 billion dollars on the Apollo space program, has received about 300 billion dollars as a result of the sale of patents alone.

The uninformed nature of our society on the work of the space sector along with departmental secrecy have led to a distorted perception of its actual spending, as well as its supposedly small contribution to the solution of vital problems of the national economy. The opinion is widespread that if we were to reduce expenditures for space or, following the calls of some public and state figures, halt research and development in the realm of space science and direct the funds freed up thereby to the development of the national economy, the country would obtain a large economic impact. Is that so? The expenses for the development of space hardware in our country were made public for the first time at the Congress of People's Deputies in 1989. It turned out that 6.9 billion rubles were expended for the program in 1989 and 6.23 billion rubles in 1990, including for the resolution of scientific, national-economic and military tasks, while the spending for 1991 will be even less owing to conversion. Spending on space science in the United States was 29.6 and 32 billion dollars respectively, and this year—including spending on the celebrated SDI military program—it will increase. Both our country and the United States spend only about one percent of their overall budgets on space programs.

The economic impact from the use of domestic space systems for national-economic purposes, in the opinion of specialists, was 19.2 billion rubles in 1986-90, and it will be 19.7-26.7 billion in 1991-1995 and 32.3-52.1 billion in 1996-2000. The profits will be greater with better organization.

Now we will compare the expenses for space hardware with individual economic indicators for our country. With an annual "space" budget of about seven billion rubles, we are suffering annual expenses of 20 billion rubles from losses of grain and six billion from losses of meat. The volume of incomplete construction is 180 billion rubles, and residual fuel and material assets beyond the standards are 247 billion rubles. It has been estimated that an acceleration of monetary circulation of just one day across the country would provide eight billion rubles. If all of the workers of the country would work without pay for just one day, they would cover the annual spending for space activity.

Today, engulfed in our own internal problems, we have largely lost the feeling of reality and have almost convinced ourselves that everything here was and is bad. Our space science today, meanwhile, is in fact the sole

sector of the national economy that remains at the leading edge of modern scientific and technical progress. To undermine this potential that has been created would mean making an obvious error whose rectification would cost us dearly.

Here is something to recall. After the tragic death of Yuriy Gagarin in March of 1968, drafts of a paper that he intended to read at a UN conference on researching outer space for peaceful purposes were found among his business papers. Those notes had these words: "Of course space flights require no small expenditures, and it would be naive to think that those expenditures will be recouped immediately, today... The penetration into space, like other great undertakings by mankind, cannot be considered only through the prism of everyday interests and routine practice. If people had been guided throughout history only by the satisfaction of their everyday needs, mankind would probably still be living in caves..."

Gagarin wrote those words without knowing that they would sound even more topical today than in his time. In the constant difficulties of our lives we have somehow forgotten that not only other worlds, but also our own earthly affairs can be seen better from the celestial heights. Cutbacks in spending for space research, like the persecution of genetics and cybernetics in their time, like the clumsy utilization of natural resources, is another of our fateful omissions. With the poorly tuned economy of the country overall, the money that would seemingly be economized in space research would also be thrown to the winds fast enough. Even during the darkest days of our country V.I. Lenin never permitted the cutback of spending for scientific research; on the contrary, he sought out ways of financing it. Space science, we are convinced, is the crest of modern science, and that cannot be forgotten.

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